shark is stated to be of mild disposition and quite harmless. Indeed, the minute size of its teeth has led to the belief in the Seychelles that it is a herbivorous fish, which, however, is not probable.

ALBERT GÜNTHER

Natural History Museum, July 30

PYROMETERS

THE accurate measurement of very high temperatures is a matter of great importance, especially with regard to metallurgical operations; but it is also one of great difficulty. Until recent years the only methods suggested were to measure the expansion of a given fluid or gas, as in the air pyrometer; or to measure the contraction of a cone of hard, burnt clay, as in the Wedgwood pyrometer. Neither of these systems were at all reliable or satisfactory. Lately, however, other principles have been introduced with considerable success, and the matter is of so much interest not only to the practical manufacturer but also to the physicist, that a sketch of the chief systems now in use will probably be acceptable. He will thus be enabled to select the instrument best suited for the particular purpose he may have in view.

The first real improvement in this direction, as in so many others, is due to the genius of Sir William Siemens. His first attempt was a calorimetric pyrometer, in which a mass of copper at the temperature required to be known is thrown into the water of a calorimeter, and the heat it has absorbed thus determined. This method, however, is not very reliable, and was superseded by his well-known electric pyrometer. This rests on the principle that the electric resistance of metal conductors increases with the temperature. In the ca-e of platinum, the metal chosen for the purpose, this increase up to 1500° C. is very nearly in the exact proportion of the rise of temperature. The principle is applied in the following manner:—A cylinder of fireclay slides in a metal tube, and has two platinum wires 100th of an inch in diameter wound round it in separate grooves. Their ends are connected at the top to two conductors, which pass down inside the tube and end in a fireclay plug at the bottom. The other ends of the wires are connected with a small platinum coil, which is kept at a constant resistance. A third conductor starting from the top of the tube passes down through it and comes out at the face of the metal plug. The tube is inserted in the medium whose temperature is to be found, and the electric resistance of the coil is measured by a differential voltameter. From this it is easy to deduce the temperature to which the platinum has been raised. This pyrometer is probably the most widely used at the present time.

Tremeschini's pyrometer is based on a different principle, viz. on the expansion of a thin plate of platinum, which is heated by a mass of metal previously raised to the temperature of the medium. The exact arrangements are difficult to describe without the aid of drawings, but the result is to measure the difference of temperature between the medium to be tested and the atmosphere at the position of the instrument. The whole apparatus is simple, compact, and easy to manage, and its indications appear to be correct at least up to 800° C.

The Trampler pyrometer is based upon the difference in in the coefficients of dilatation for iron and graphite, that of the latter being about two-thirds that of the former. There is an iron tube containing a stick of hard graphite. This is placed in the medium to be examined, and both lengthen under the heat, but the iron the most of the two. At the top of the stick of graphite is a metal cap carrying a knife-edge, on which rests a bent lever pressed down upon it by a light spring. A fine chain attached to the long arm of this lever is wound upon a small pulley; a larger pulley on the same axis has wound upon it a second chain, which actuates a third pulley on the axis of the indicating needle. In this way the relative dilatation of the graphite is sufficiently magnified to be easily visible.

A somewhat similar instrument is the Gauntlett pyrometer, which is largely used in the north of England. Here the instrument is partly of iron, partly of fireclay, and the difference in the expansion of the two materials is caused to act by a system of springs upon a needle revolving upon a dial.

The Ducomet pyrometer is on a very different principle, and only applicable to rough determinations. It consists of a series of rings made of alloys which have slightly different melting-points. These are strung upon a rod, which is pushed into the medium to be measured, and are pressed together by a spiral spring. As soon as any one of the rings begins to soften under the heat, it is squeezed together by the pressure, and, as it melts, it is completely squeezed out and disappears. The rod is then made to rise by the thickness of the melted ring, and a simple apparatus shows at any moment the number of rings which have melted, and therefore the temperature which has been attained. This instrument cannot be used to follow variations of temperature, but indicates clearly the moment when a particular temperature is attained. It is of course entirely dependent on the accuracy with which the melting-points of the various alloys have been fixed.

Yet another principle is involved in the instrument called the Thalpotasimeter, which may be used either with ether, water, or mercury. It is based on the principle that the pressure of any saturated vapour corresponds to its temperature. The instrument consists of a tube of metal partly filled with liquid, which is exposed to the medium which is to be measured. A metallic pressure gauge is connected with the tube, and indicates the pressure existing within it at any moment. By graduating the face of the gauge when the instrument is at known temperatures, the temperature can be read off directly from the position of the needle. From 100° to 220° F. ether is the liquid used, from thence to 680° it is water, and above the latter temperature mercury is employed.

Another class of pyrometers having great promise in the future is based on what may be called the "water-current" principle. Here the temperature is determined by noting the amount of heat communicated to a known current of water circulating in the medium to be observed. The idea, which was due to M. de Saintignon, has been carried out in its most improved form by M. Boulier. Here the pyrometer itself consists of a set of tubes one inside the other, and all inclosed for safety in a large tube of fireclay. The central tube or pipe brings in the water from a tank above, where it is maintained at a constant level. The water descends to the bottom of the instrument and opens into the end of another small tube called the explorer (*explorateur*). This tube projects from the fireclay casing into the medium to be examined, and can be pushed in or out as required. After circulating through this tube the water rises again in the annular space between the central pipe and the second pipe. The similar space between the second pipe and the third pipe is always filled by another and much larger current of water which keeps the interior cool. The result is that no loss of heat is possible in the instrument, and the water in the central tube merely takes up just so much heat as is conducted into it through the metal of the explorer. This heat it brings back through a short indiarubber pipe to a casing containing a thermometer. This thermometer is immersed in the returning current of water and records its temperature. It is graduated by immersing the instrument in known and constant temperatures, and thus the graduations on the thermometer give at once the temperature, not of the current of water, but of the medium from which it has received its heat.

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In order to render the instrument perfectly reliable, all that is necessary is that the current of water should be always perfectly uniform, and this is easily attained by fixing the size of the outlet once for all, and also the level of water in the tank. So arranged, the pyrometer works with great regularity, indicating the least variations of temperature, requiring no sort of attention, and never suffering injury under the most intense heat; in fact the tube, when withdrawn from the furnace, is found to be merely warm. If there is any risk of the instrument getting broken from fall of materials or other causes, it may be fitted with an ingenious self-acting apparatus shutting off the supply. For this purpose the water which has passed the thermometer is made to fall into a funnel hung on the longer arm of a balanced lever. With an ordinary flow the water stands at a certain height in the funnel, and, while this is so, the lever remains balanced; but if from any accident the flow is diminished, the level of the water in the funnel descends, the other arm of the lever falls, and in doing so releases two springs, one of which in flying up rings a bell, and the other by detaching a counterweight closes a cock and stops the supply of water altogether.

It will be seen that these instruments are not adapted for shifting about from place to place in order to observe different temperatures, but rather for following the variations of temperature at one and the same place. For many purposes this is of great importance. They have been used with great success in porcelain furnaces, both at the famous manufactories at Sèvres and at another porcelain works in Limoges. From both these establishments very favourable reports as to their working have been received. W. R. BROWNE

THE AGRICULTURAL INSTITUTE OF BEAUVAIS

WE have already referred to the interesting collection exhibited in the Technical School at the Health Exhibition by the Brothers of the Christian Schools. One of the most instructive of their specimen museums is that from their Agricultural Institute at Beauvais.

This Institute was founded in 1855, the late Prince Consort being one of its first patrons. Recently the Agronomical Society of France have extended to it an encouraging hand.

Candidates for admission to the school must be at least sixteen years of age, and must give evidence, either by certificates obtained or by a preliminary examination, of their having successfully studied the recognised branches of a good modern education. The course of instruction extends over a period of three years, and is intended to prepare young men to manage and develop estates and direct all farming operations. Special provision is made, in the third year, for those who wish to qualify themselves for agricultural professorships. The syllabus of subjects is framed by a Board appointed by the prefect of the *département*, and consists of the Director and Professors of the Institute, of the Professor of Agriculture, and the Veterinary Surgeon of the *département*, as also of three other members.

The subjects for the first year are: French language, book-keeping and commercial subjects, elementary algebra and geometry, the fundamental principles of agriculture, rural law and engineering, general zoology, arboriculture, horticulture, physics, chemistry, and linear drawing.

In the second year the students follow more advanced courses of agriculture, zoology, botany, entomology, geology, surveying, levelling, physics, general and analytical chemistry, rural law and engineering, linear drawing, arboriculture, and horticulture.

The instruction for the last year comprises agriculture, arboriculture, horticulture, analytical chemistry, botany, geology, entomology, applied mathematics and mechanics, and architectural drawing.

Science teaching, to be of any use, must be practical; the authorities of the Agricultural Institute, fully convinced of this, attach great importance to laboratory and field work. In the physical laboratory, the work is exclusively of a demonstrational kind, the students not being required to test the accuracy of their knowledge or their familiarity with instruments by the actual and precise measurement of physical constants. Nor do such measurements appear necessary for the object in view. It is, of course, quite different with chemistry, where skill in quantitative analysis is of the highest value to any one who intends to direct the agricultural interests of a district. The students are consequently trained with much care in those branches of analytical chemistry which bear directly upon the science of agriculture. The study of botany, geology, and entomology is encouraged and stimulated by frequent excursions to the neighbouring country, the specimens brought back being compared, classified, and minutely described in appropriate language.

The school has also a model farm of 325 acres, in which the principal operations of farming are extensively carried on. The students visit this farm at stated hours every week; they are familiarised with the chief implements and agricultural appliances, and are required to take part in all the regular work that may be going on.

The Professors have set aside a number of acres for experimenting upon the conditions most favourable to the growth of the principal cereals. These comparative studies are carried out with the assistance of the students mainly for the purpose of showing them how to practically initiate a scientific investigation of an agricultural nature. The results of these studies are fully described in the *Annales de l'Institut agricole*, a yearly publication of considerable merit. A valuable synopsis of the results obtained by the Director of the School, Brother Eugene, will be found in the Educational Section of the International Health Exhibition, Room 5.

From a recent report, we find that there have been, this year, under cultivation no less than sixty-five kinds of wheat, twenty of oats, ten of barley, eight of rye, besides fields of potatoes, beetroot, cabbage, &c. There are also pasture lands for sheep and cows, and a well-stocked poultry yard.

At the end of each year the students are put through a practical examination, when they are expected to give satisfactory evidence of their competency to deal with the general working of the farm. It is also required by the programme of the Institute that the students shall visit exhibitions of an agricultural character which may be held in the vicinity, and attend with their Professors certain markets and sales of live stock.

The attention of the students is maintained and quickened by requiring them to write, with considerable care, notes of all their courses, as well as detailed reports of what they may have seen in their visits or met with in their excursions. Several volumes of these reports, notes, and theses, together with typical herbaria, specimens of grain and seeds, may be seen in the Exhibition, Room 5.

Besides superintending the museum and giving instruction in the laboratories, the Brothers teach drawing, physics, chemistry, botany, geology, zoology, &c., leaving such subjects as rural jurisprudence and engineering, agriculture, and the like to other eminent professors.

IS SALPA AN EXAMPLE OF ALTERNATION OF GENERATIONS?

THE chances against the accidental discovery of a great natural law are so great that we cannot feel surprise that naturalists are slow to believe that Salpa,

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